CESPK-ED-SC 18 June 2012

(25 Feb 2013 REV)

MEMORANDUM FOR FILE: Sutter Basin Pilot Feasibility Study

SUBJECT: Estimated Project Cost for Draft Array of Alternatives Comparison

1. REFERENCES:

a. Recommendation for Transforming the Current Pre-Authorization Study Process, USACE, January 2011.

2. PURPOSE:

The purpose of this memorandum is to describe and document the method used to calculate the estimated cost of the draft array of alternatives for the Sutter Basin Pilot Feasibility Study.

3. BACKGROUND:

The Sutter Basin Feasibility Study was selected as a planning pilot study to test principles that have been outlined in the *USACE Recommendations for Transforming the Current Pre-Authorization Study Process* (January 2011) and associated presentation materials.

The Pilot Study Re-scoping Plan described an approach to evaluating and comparing alternatives. The beneficial and adverse effects, including monetary and non-monetary benefits and costs, were to be identified for each alternative across a broad array of criteria. The potential criteria to be used included the four P&G criteria (completeness, effectiveness, efficiency, acceptability), national economic development, environmental quality, regional economic development, other social effects (including public safety), environmental justice, sustainability, promotion of wise use of the floodplain in accordance with EO 11988, residual risk, and the consequences of project failure. The beneficial and adverse effects for each alternative in relation to each of the evaluation criteria would be determined based on available information as well as the professional judgment and local knowledge of SMEs and the PDT. The following table presents potential criteria and evaluation methods currently being evaluated for evaluation of the draft array of alternatives.

Criteria	**Evaluation Method For Draft Array of Alternatives**
Net economic benefits	Expected annual damage and costs.
ER benefits	Estimated acreage of habitat based on GIS/aerial photography.
Cost	Estimated cost based on a level 4 estimate (ER 110-2-1302)
Public Safety	Annualized population at risk (PAR).
Wise Use of Floodplain	Potentially developable land within the 0.2% (1/500) Annual Chance Exceedance floodplain.
Non-federal standard	Does alternative meet State's requirement of reducing the risk of flooding to urban and urbanizing areas to less than 0.5% (1/200) Annual Chance of Exceedance.

Critical Infrastructure	Describe number of critical infrastructure items within the 1% ACE floodplain (FEMA type approach).

4. APPROACH:

a. Cost Estimates

In developing the reconnaissance level cost estimates of the various measures and alternatives (combined measures) for the Sutter Basin project, the Cost Engineering team utilized a methodology wherein costs for levee improvements or new levees (sans relocations) were developed using a parametric spreadsheet based on typical cross sections for differing types of levee improvements. Costs for relocations and construction other than that directly related to the levee were compiled based on either 1) historical costs - past levee projects in the vicinity of Sacramento, 2) estimating software MII (MCACES, 2nd Generation) and PACES, or 3) based on a percentage of construction costs. In lieu of the time constraints of the 24-month fast-track pilot study schedule, these methods were used for preparing costs for the purpose of screening alternatives.

A spreadsheet developed by URS Corporation was selected to prepare the parametric level cost estimates for levee improvements and new levees. The parametric spreadsheet utilizes unit costs of certain typical levee design parameters including, for example, stripping vegetation, earthwork, cutoff walls, etc. The spreadsheet is essentially a collection/database of unit cost data from public bid results and projects that URS worked on for the California Department of Water Resources and other various public agencies. The parametric spreadsheet is thus believed to produce an effective and reliable estimate. Input data for followed typical levee designs provided by the Sacramento District (SPK) Geotech/Civil Design sections and the spreadsheet computed the corresponding construction cost. The estimate is based on the manual inputs and output is based solely on the input. The project delivery team (PDT) determined recommended repairs (or new levee design) based on hydraulic models and representative geotechnical data. For each individual reach and cross section, parameters such as the levee height, crest width, levee slopes, cutoff wall depths, etc., were quantified and used to generate the input data. The unit prices used were reviewed by SPK Cost Estimating Section and updated to reflect present day costs. In some cases, these unit costs were updated based on costs developed in MII. (Please refer to the “Parametric Cost Estimating MII Toolbox” pdf file for the parametric cost estimates of alternatives).

Besides levee improvements, other major cost categories including roads, railroads and canals crossing new levees, utility relocations, interior drainage, traffic control, SWPP, cultural resources, mitigation, PED (Planning, Engineering & Design), and Construction Management had to be considered separately. The costs for work relative to obstructions/structures crossing levees (special items) and interior drainage (pump stations) were based on preliminary quantity take-offs, hydrological analysis and existing cost data or similar historic cost estimates. A percentage of the construction cost was used to compute costs for the remaining cost categories.

The cost estimate for each Alternative is the summation of the costs from the parametric spreadsheet output and the costs of each of the other major cost categories.

The Screening Level Estimates were developed based on the initial measures and these were combined to reflect the alternatives developed by the PDT. The estimates were continuously updated to match the current design refinements and the latest information available at the time of the revisions. The costs do not account for life cycle costs.

The estimates follow the Civil Works Work Breakdown Structure (CWWBS) code of accounts. Feature Codes typically involved in this estimate are 01- Lands and Damages, 02-Relocations, 06-Fish and Wildlife Facilities, 11-Levees and Floodwalls, 18-Cultural Resource Preservation, 30-Planning, Engineering and Design, and 31-Construction Management. The 30 and 31 accounts involve any costs associated with USACE staffing on the project. The amounts are based on historical data.

b. Cost Uncertainties

There are inherent uncertainties in the costs at the feasibility level of design since there is no detailed design, plans or specs. There are also inherent uncertainties as the construction contractor(s) are responsible for obtaining most construction materials, accomplishing the work in a timely manner as per the project due date, using overtime and/or multiple crews to accomplish the same, etc. There are also many cost uncertainties relative to risk analysis (see below).

For this project, more than 50% of the costs for this project are directly related to levee improvements or new levee construction. A large percentage of this is obtaining and hauling fill material. For the purposes of the cost estimate, the assumption has been made that materials will come from within 10 miles (one-way haul). The potential contractors are free to obtain borrow from wherever they see fit, as long as it meets specs. Haul costs in general have some uncertainty as material supply locations are up to the contractor, as well as whether the contractor use their own trucks or utilize a subcontractor for hauling.

c. OMRR&R Costs

An investigation into OMRR&R costs was done by the local sponsor by soliciting information from various Levee Districts and State Maintenance Agencies within the Sutter Basin. The costs presented in the attached Table 1 at the end of this section are based on this info. The OMRR&R cost is an estimate of how much effort the local sponsor needs to perform on an annual basis. In the without-project condition, it is assumed that that the locals have carried out the current OMRR&R commitments.

For this exercise, an incremental (Δ) or additional OMRR&R cost was determined. Based on the information provided for the year 2010-2011, there is approximately 63.6 miles of levee maintained by the LDs and MAs (LD1, LD9, MA3, MA7, MA17, and East Levee Sutter Bypass) with an actual expenditure of $980,000. This equates to a unit cost of approximately $15,400 per mile of levee. In the final array of alternatives, only Alternatives SB-3 “Yuba Ring Levee” and SB-4 “Little J Levee” have new levees and therefore would incur additional O&M cost. Alternative SB-3 and SB-4 have 13.5 miles and 10.3 miles of new levee respectively. Multiplying by the unit cost, the additional annual maintenance cost for Alternatives SB-3 and SB-4 is approximately $210,000 and $160,000 respectively. The additional OMRR&R cost can have an influence in the screening of the Alternatives.

d. Total Project Schedule (including Construction)

No formal construction schedule has been developed, but the assumption has been made that the PED portion of the project will occur in FY 13 thru FY 15 with the construction portion commencing FY 16. Construction is assumed to take 3 to 7 years, depending on the alternative.

e. Cost and Schedule Risk Analysis

An initial Cost & Schedule Risk Analysis (CSRA) was performed for the project. The risk analysis process used is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve any desired level of cost confidence. A parallel process was also used to determined the probability of various project schedule duration outcomes and quantify the required schedule contingency (float) needed in the schedule to achieve any desired level of schedule confidence. Risk analysis results are intended to provide project leadership with contingency information in order to support decision making and risk management as the project progresses from planning through implementation. To fully recognize its benefits, cost and schedule risk analysis should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and execution plan development, resource planning, procurement planning, budgeting and scheduling.

A meeting was held 25-26 April 2012 with the project manager, most PDT members, and representatives of the local sponsor. The meeting focused primarily on risk factor identification using brainstorming techniques, but also included some discussions based on risk factors common to many civil works projects. The meeting included risk factor assessment and quantification and did result in some revisions to the estimate. Project risks were identified and a risk register developed as a spreadsheet (using Microsoft Excel). After the meeting, the draft risk register was forwarded to the PDT for review.

Risk models were developed for each alternative based on the items with moderate or high risk. Low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as to support follow-on risk studies as the project and its accompanying risks evolve. Some of the moderate/high risk items were mitigated somewhat by further design and additions to the cost estimate. The remaining risks were used to calculate and present the cost and schedule contingencies.

The quantitative impacts of each risk element on costs and schedule were analyzed using a combination of professional judgment, empirical data and analytical techniques. Risks were quantified using probability distributions because risk factors are entered into Crystal Ball software (an add-on to Microsoft Excel) in the form of probability density functions. Quantification involved multiple project team disciplines and functions. This process used an iterative approach to estimate the following parameters for each risk element:

- Maximum possible value for the risk element
- Minimum possible value for the risk element
- Most likely value (the statistical mean), if applicable
- Nature of the probability density function used to approximate risk element uncertainty
- Mathematical correlations between risk elements
- Affected cost estimate and schedule elements

The resulting product risk model therefore reflects the risk register parameters as developed by the PDT.

In simple terms, contingency is an amount added to an estimate and/or schedule that allows for items, conditions or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. Contingency was analyzed using the Crystal Ball software. *Monte Carlo* simulations were performed by applying risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. A simulation calculates multiple trials for the model by repeatedly sampling values from the probability distributions. During each trial, Crystal Ball randomly selects a value from the defined possibilities (based on the range and shape of the probability distribution) for each variable and then recalculates the cost and schedule risk analysis spreadsheet.

Cost variances are calculated by simulating the probable effects of the risk elements to the construction cost estimate. Contingencies are then calculated by applying probability of cost variance occurrence. The sum of the model cost variances is the resultant cost risk for the project. The contingency is calculated based on the difference between the sum of the cost risks and the base cost estimate. Note that cost risks are not always the same as schedule risks.

The Sacramento District has also found that historically, there is a comparative difference between the inflation rates from the Civil Works Construction Cost Index System (CWCCIS) rates and the local Sacramento area historical inflation rate. This has been modeled as an additional risk with added cost contingency based on 1) inflation rates higher than CWCCIS rates and 2) the affect of project delays from the schedule analysis.

For schedule contingency analysis, the potential delays to start of construction or delays during construction are also modeled based on the likelihood of these delays and the possible duration (as determined by the PDT). The effect on schedule is entered into the Crystal Ball model as the potential schedule variance. The sum of the model schedule variances is the resultant schedule risk. The contingency for the schedule is calculated as the difference between the sum of the schedule risks and the base construction schedule.

The amount of contingency used for a project depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that is acceptable, the more contingency that must be applied. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost Engineering MCX guidance for cost and schedule risk analysis generally focuses on the eighty-percent level of confidence (P80) for cost contingency calculation. The P80 confidence level is the standard normally provided to Congress by USACE and other agencies. Total Project Cost (TPC) being the base costs times the contingency percentage (80% confidence level), there would be an 80% chance of final costs falling at or below the Total Project Cost value. Conversely, there is a 20% chance that the TPC would be above this value.

f. Review

The screening level cost engineering data has been reviewed by senior estimators at the Sacramento District.

g. Screening Level Results

The tables at the conclusion of this section show a brief summary of the screening level results.

5. KEY ASSUMPTIONS:

a. Parametric Estimates

- Cross Sections for the various levee improvements or new levees are representative of the levee reach.
- Unit Costs utilized are fair and reasonable.

b. Haul Distances – Levee Fill Borrow will come from within 10 miles (one-way haul).

c. Real Estate - Real Estate Costs are reasonable.

d. PACES estimates developed for some special items are sufficient for this level of design (screening alternatives).

e. Quantity Uncertainty - Where design is insufficient to produce quantities, the percentage of construction costs assumed and used for unknown utilities, SWPP, mitigation, etc. represent costs adequate to screen alternatives to the point of determining a tentatively selected plan.

f. Project Schedule - PED portion of the project will occur from FY 13 thru FY 15 with the construction portion commencing FY 16. Construction is assumed to take 3 to 7 years

g. Cultural Resources – Costs will be approximately 1% of the Federal Construction Costs

h. PED Costs – the assumed 18% of Construction Costs used in recent years by the Sacramento District is fair and reasonable

i. Construction Management Costs – the assumed 8.5% of Construction Costs used in recent years by the Sacramento District is fair and reasonable

6. RESULTS

Table 1
Estimated Cost Without Contingency for Draft Array of Alternatives

Item	COST ($1000)							
	SB-1	SB-2	SB-3	SB-4	SB-5	SB-6	SB-7	SB-8
	No Action	Minimal Fix In Place with Non Structural	Yuba City Ring Levee	Little J-Levee	Fix-In-Place Feather River, Thermalito to Star Bend	Fix-In-Place Feather River, Sutter Bypass, Wadsworth Canal	Fix-In-Place Feather River, Sunset Weir to Laurel Ave	Fix-In-Place Feather River, Thermalito to Laurel Ave
6 Fish & Wildlife Fac		16,590	22,804	40,014	31,225	57,310	21,966	36,601
11 Levees & Floodwalls		149,604	190,469	353,095	284,203	502,953	200,207	334,806
18 Cult. Resrc. Preserv.		1,627	2,252	3,978	3,004	5,512	2,160	3,537
1 Lands & Damages (FED)		3,865	3,850	9,775	5,500	9,175	4,895	6,500
30 PED (FED)		29,915	38,389	70,760	56,777	100,847	39,991	66,853
31 Construction Mngt (FED)		14,126	18,128	33,414	26,811	47,622	19.994	31,569
1 Lands & Damages (NF)		13,076	21,746	39,261	17,536	32.886	18,381	22,841
2 Relocations (NF)		16,297	37,580	47,045	28,051	70,150	19,450	31,204
30 PED (NF)		2,933	6,764	8,468	5,049	12,627	3,501	5,617
31 Construction Mngt (NF)		1,385	3,194	3,999	2,384	5,963	1,653	2,652
TOTAL (FED & NF)		249,448	345,176	609,809	460,540	845,045	331,088	542,180
	COST ($1000/YR)							
Δ OMRR&R		0	210	160	0	0	0	0

* OMRR&R cost is based on 2010-2011 actual expenditures provided by local Levee Districts and the State Maintenance Areas.

Table 2
Estimated Contingency for Draft Array of Alternatives

Percent Chance Cost will be lower than stated amount	Contingency (%)							
	SB-1	SB-2	SB-3	SB-4	SB-5	SB-6	SB-7	SB-8
	No Action	Minimal Fix In Place with Non Structural	Yuba City Ring Levee	Little J-Levee	Fix-In-Place Feather River, Thermalito to Star Bend	Fix-In-Place Feather River, Sutter Bypass, Wadsworth Canal	Fix-In-Place Feather River, Sunset Weir to Laurel Ave	Fix-In-Place Feather River, Thermalito to Laurel Ave
0.01		-1.22	-3.02	1.05	-1.15	-1.95	-1.32	-1.24
10%		11.76	14.31	14.86	13.96	14.88	12.18	14.27
20%		16.45	19.08	19.49	19.30	20.48	17.09	19.79
25%		18.34	21.02	21.49	21.43	22.72	19.05	21.99
30%		20.22	22.97	23.49	23.56	24.95	21.02	24.19
40%		23.80	26.62	26.98	27.56	29.17	24.76	28.32
50%		27.71	30.52	30.83	31.99	33.80	28.87	32.90
60%		32.28	34.96	35.31	37.03	39.11	33.67	38.13
70%		37.58	40.12	40.53	42.88	45.38	39.19	44.21
75%		41.07	43.52	43.96	46.74	49.44	42.85	48.20
80%		44.55	46.92	47.38	50.59	53.50	46.51	52.20
90%		54.09	56.79	57.20	61.41	64.90	56.49	63.40
99%		89.28	94.58	95.61	101.55	106.62	93.44	104.87

Table 3
Estimated Total Project Cost for Draft Array of Alternatives

Percent Chance Cost will be lower than stated amount	Project Cost ($1000)							
	SB-1	SB-2	SB-3	SB-4	SB-5	SB-6	SB-7	SB-8
	No Action	Minimal Fix In Place with Non Structural	Yuba City Ring Levee	Little J-Levee	Fix-In-Place Feather River, Thermalito to Star Bend	Fix-In-Place Feather River, Sutter Bypass, Wadsworth Canal	Fix-In-Place Feather River, Sunset Weir to Laurel Ave	Fix-In-Place Feather River, Thermalito to Laurel Ave
0.01		246,405	334,752	616,212	455,244	828,567	326,718	535,457
10%		278,784	394,571	700,427	524,832	970,788	371,415	619,549
20%		290,483	411,036	728,661	549,425	1,018,111	387,671	649,477
25%		295,197	417,732	740,857	559,234	1,037,040	394,160	661,405
30%		299,887	424,463	753,054	569,044	1,055,884	400,683	673,333
40%		308,817	437,062	774,336	587,465	1,091,545	413,065	695,725
50%		318,571	450,524	797,814	607,867	1,130,671	426,673	720,557
60%		329,970	465,850	825,133	631,078	1,175,543	442,565	748,913
70%		343,191	483,661	856,965	658,020	1,228,527	460,841	781,878
75%		351,897	495,397	877,882	675,797	1,262,836	472,959	803,511
80%		360,578	507,133	898,737	693,528	1,297,145	485,077	825,198
90%		384,375	541,202	958,620	743,358	1,393,480	518,120	885,922
99%		472,156	671,664	1,192,848	928,219	1,746,032	640,457	1,110,764

NOTE: All costs are considered preliminary and are only to be used to compare the relative cost between the draft array of alternatives. Focus on the Cost Engineering data has been on the alternatives. The costs for the possible options will be updated following determination of the tentatively selected plan (TSP). Once the PDT has selected the TSP and any locally preferred plan (if different from the TSP), Feasibility Level Details and Cost Engineering data must be developed. This includes creation of the initial designs, civil design plans, a materials balance, development of an MII estimate, Project and Construction Schedules, PDT estimates for Planning, Engineering and Design and Construction Management, an updated Cost and Schedule Risk Analysis and a Total Project Cost Estimate extending costs out through the life of the Project. The MII estimate must be detailed indicating labor, equipment and materials with accompanying production rates.